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Bio-floc Technology (BFT): A Natural Tool of Bioremediation to Clean the Lentic Water Environment and Cost-Effective Novel Technology for the Fish Industry

S Rehan Ahmad*

Dept. of Zoology Hiralal Mazumdar Memorial College for Women

Dakshineswar, Kolkata, West Bengal

*Corresponding Author E-mail: zoologist.rehan@gmail.com

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ABSTRACT

The current work aims to examine the significance of Bio-floc technology in aquaculture as a powerful bioremediation tool for environmental issues, a way of reducing poverty, and a method of ensuring future food security. Aquaculture's expensive feed can be replaced with biofloc technology (BFT), which has the added benefit of improving the environment without adding any further costs. The Biofloc system is economical since it requires no water exchange, which lowers the cost of an exchange. BFT encourages and modifies the carbon-to-nitrogen ratio (C/N) and convents hazardous metabolites to microbial flocs, preventing the build-up of hazardous nitrogen metabolites (NH_3, NO_2, etc.). In addition to serving as a valuable protein input, the presence of numerous bacterial groups, particularly Bacillus sp. and Lactobacillus sp., suggests that biofloc may also become a rich source of probiotics. BFT can be utilized as a cost-effective solution to lower the weight of fish consumed commercially while also minimizing any potential environmental issues. The ingestion of macro aggregate can boost nitrogen retention from additional feed by 7 to 13%. Therefore, it may be said that BFT has paved the way for its usage as a substitute diet. Finally, we can state that it is a method that improves the environment without adding any more expense.

Keywords: *Bio-floc technology, Bioremediation, Lentic Water, Water Pollution, Fish Production.*

INTRODUCTION

The supply of edible fish has increased at an average annual pace of 3.2% over the past 50 years, exceeding the 1.6% expansion in the global population (FAO, 2014). Aquaculture is rapidly becoming more intensive, and the high feed input and high stocking density are causing environmental problems. Hargreaves JA defined BFT as the retention of waste and its conversion to biofloc as a natural food within the culture system (Hargreaves, 2006).

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BFT also makes it possible to intensify at a reasonably low initial investment and ongoing operational cost (Avnimelech, 2011).

Maintaining a high carbon/nitrogen (C/N) ratio in the water to promote the growth of heterotrophic bacteria that convert ammonia into microbial biomass is the primary idea behind nutrient recycling (Avnimelech, 1999). The microorganisms' two main functions are to increase culture feasibility by lowering the feed conversion ratio and feed costs and to maintain water quality by absorbing nitrogen compounds and producing "in-situ" microbial protein. BFT is a genuine "green" system with an "environmentally friendly" outlook.

Among the bacterial supplements are microbial flocs natural food to promote growth, competitive exclusion to stop the spread of pathogens, and immuno-stimulation of the target organisms' immune systems (El-Haroun et al., 2006; Verschuere et al., 2000; & Ganguly et al., 2010). In large shrimp ponds, adding carbohydrates increased nitrogen retention effectiveness and boosted productivity (Hari et al., 2004; & Mandal, 2017). As evidenced by harmful Vibrio species in shrimp aquaculture, yeast can reduce pH in biofloc medium by converting carbohydrates into lactic acid by the Lactobacillus spp. while also preventing the spread of pathogens (Ma et al., 2009).

Aims & Application of BFT Technology:

Since nutrients can be continuously recycled and reused, the ecologically friendly aquaculture method known as **"Biofloc Technology (BFT)"** is regarded as an effective alternative technique. Such a system's sustainable design is based on the growth of microorganisms in the culture medium, which is aided by little to no water exchange. These bacteria (Biofloc) have two key roles: (i) maintain water quality through the uptake of nitrogen molecules, producing "in situ" microbial protein, and (ii) enhance nutrition by lowering feed conversion ratios and feed costs to increase culture feasibility.

As a closed system, BFT has the primordial advantage of minimizing the release of water into rivers, lakes, and estuaries containing escaped animals, nutrients, organic matter, and pathogens. Also, surrounding areas are benefitted from the “vertical growth” in terms of productivity, preventing coastal or inland area destruction, induced eutrophication**,** and natural resources losses. The nitrogen and phosphorus levels in the water that is drained from ponds and tanks are frequently very high, restricting the nutrients that encourage the growth of algae. This can lead to severe eutrophication and worsen anaerobic conditions in natural water bodies. BFT transforms such a system into a true "environmentally friendly system" with a "green" approach by minimizing water outflow and reusing water. A minimal water exchange keeps the heat in place and prevents temperature fluctuations, allowing tropical species to flourish in cold climates.

The role of microorganisms in BFT aquaculture systems

Microbes are essential to BFT systems. A high carbon-to-nitrogen (C: N) ratio is used to maintain water quality because heterotrophic bacteria can readily absorb nitrogenous by-products, which are mostly controlled by the bacterial population over autotrophic microorganisms. Heterotrophic bacteria use this energy for maintenance (respiration, eating, motility, digestion, etc.), as well as for growth and to form new bacterial cells, hence a high carbon-to-nitrogen ratio is necessary to ensure optimum growth.

The dynamic interaction between populations of bacteria, microalgae, fungi, protozoans, nematodes, rotifers, etc., that will naturally arise ensures zero or little water exchange stability. These microbial alliances will aid in preserving water quality and recycling trash to create high-quality food. In aquaculture, organic matter and nitrogen wastes are major issues. The most significant contributors to the reutilization of nitrogen and

OM are phytoplankton, heterotrophic organisms, and nitrifying bacteria. In addition to the cultivated species, fungi, ciliates, protozoa, rotifers, copepods, and nematodes contribute to the biofloc community by recycling organic matter as a component of intricate food webs.

One current practice in BFT is the use of commercial bacteria consortia (probiotics). The main reasons probiotics used in BFT are (i) help to stabilize the heterotrophic community and to compete with autotrophic microorganisms (mainly in the initial phases), (ii) help to recycle the organic matter, and (iii) control solids and TAN levels.

Bacteria

In biofloc systems, heterotrophic bacteria colonize waste products including molts, dead animals, and uneaten food to produce bacterial biomass that detritivores eat. According to Brown et al. analysis's of the biochemical makeups of seven strains of marine bacteria, the protein content (dry weight) ranged from 29 to 49%, while the amounts of carbohydrates, lipids, and essential amino acids were also present.

The oxidation of harmful nitrogen molecules provides energy to the chemoautotrophic bacterial community, which includes the nitrifying bacteria. The occurrence of ammonia, nitrite, and the build-up of flocculated materials all naturally encourage the nitrifying bacteria (used as substrate). These microbes require an alkalinity source to replace the alkalinity they consume, such as sodium bicarbonate, calcium carbonate, or calcium hydroxide. Ammonia oxidizing bacteria's generation period in lab settings was calculated to be 25 hours, while nitrite-oxidizing bacteria's development time was 60 hours.

The nitrifying bacteria can flourish in a wide range of environments. The biggest problem with biofloc systems besides oxygen is toxic nitrogen compounds. The main sources of ammonia are the excrement of domesticated species and the decomposition of non-living materials (dissolved and particulate).

A photoautotrophic removal by algae, an autotrophic bacterial conversion from ammonia to nitrate, and a heterotrophic bacterial conversion of ammonia nitrogen straight to microbial biomass are the three nitrogen conversion mechanisms that take place in BFT. The most effective process over the long term is autotrophic, which involves two bacterial groups: (a) the ammonia-oxidizing bacteria, which convert unionized ammonia to nitrite for energy; these include the genera *Nitrosomonas*, *Nitrosococcus*, *Nitrosospira, Nitrosolobus,* and *Nitrosovibrio*; and (b) the nitrite-oxidizing bacteria, which convert nitrite to a nitrate; these include the genera.

Main water quality parameters in BFT

In aquaculture, maintaining and monitoring water quality is crucial for the success of the growing cycles. The following characteristics should be continually checked, especially in BFT: temperature, dissolved oxygen (DO), pH, salinity, solids (total suspended solids (TSS) and settling solids), alkalinity, and orthophosphate. The proper growth and upkeep of the production cycle depend on understanding the water quality factors and how they interact in BFT. For instance, maintaining safe levels of pH, DO, solids, total ammonia nitrogen (TAN), and alkalinity will promote healthy growth and prevent fatalities. The autotrophic community that will exist in the system will be influenced by the N:P ratio (often utilizing nitrate and orthophosphate concentrations) (e.g., chlorophytes versus cyanophytes). Table 01 lists the same normal ranges and/or recommended ranges for tropical species (such as tilapia and marine shrimp *Litopenaeus vannamei*) as in BFT.

Table – 1 (Parameter of BFT)

Parameter	Ideal and/or normal observed ranges	Observations
Dissolved oxygen (DO)	Above of 4.0 mg L^{-1} (ideal) and at least 60% of saturation	For correct fish, shrimp, microbiota respiration, and growth
Temperature	28–30° (ideal for tropical species)	Besides fish/shrimp, low temperatures (~20° C) could affect microbial development
pH	6.8–8.0	Values less than 7.0 is normal in BFT but could affect the nitrification process
Salinity	Depends on the cultured species	It is possible to generate BFT, e.g., from 0 to 50 ppt
TAN	Less than 1 mg L^{-1} (ideal)	Toxicity values are pH dependent
Nitrite	Less than 1 mg L^{-1} (ideal)	Critical parameter (difficult to control). Special attention should be done, e.g., on protein level of feed, salinity, and alkalinity
Nitrate	0.5–20 mg L^{-1}	In these ranges, they are generally not toxic to the cultured animals
Orthophosphate	0.5–20 mg L^{-1}	In these ranges, they are generally not toxic to the cultured animals
Alkalinity	More than 100 mg L^{-1}	Higher values of alkalinity will help the nitrogen assimilation by heterotrophic bacteria and the nitrification process by chemoautotrophic bacteria
Settling solids (SS)	Ideal: 5–15 mL L^{-1} (shrimp), 5–20 (tilapia fingerlings) and 20–50 mL L^{-1} (juveniles and adult tilapia)	High levels of SS (measured in Imhoff cones) will contribute to the DO consumption by the heterotrophic community and gill occlusion
Total suspended	Less than 500 mg L^{-1}	Idem to SS

CONCLUSION

Aquaculture uses the environmentally friendly and sustainable biofloc technique to preserve the water quality by turning nitrogenous waste into bacterial proteinaceous biomass after adding carbohydrate sources, which the aquaculture aquatic animals can then ingest. Although any carbohydrate can be utilized as a carbon source, shrimp and fish farms typically use sugar cane molasses. The effects of various carbon sources on the microbial population and biofloc production in extremely intense aquaculture conditions with no water exchange need to be further researched.

Finding out how additional carbon sources affect shrimp performance and water quality maintenance is also necessary. In this region of the world, where the aforementioned species have enormous potential in the freshwater farming system, there is a dearth of literature on the development and environmental performances of BFT in fin fish like tilapia and common carp. Future researchers should also focus on comparison studies using variable test fish, variable media composition, and variable feeding regimes under various levels of crude protein and feeding rate.

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ORCID id: https://orcid.org/0000-0003-0796-5238

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